

Scalable Majorana Devices

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Majorana zero modes have received widespread attention due to their potential to support topologically protected quantum computing [1]. Emerging as zero-energy states in one-dimensional semiconductors with induced superconductivity, Zeeman coupling, and spin-orbit interaction [2, 3], Majorana modes have been primarily investigated in individual InSb or InAs nanowires [4–8], including recently realized epitaxial hybrid nanowires [9–11]. Tests of non-Abelian statistics of Majoranas involve braiding [12, 13] or interferometric measurement [14–16], requiring branched geometries, which are challenging to realizing using nanowire growth. Scaling to large networks using arrays of assembled nanowire also appears difficult. Here we explore signatures of Majorana zero modes in devices made from a two-dimensional heterostructure [17, 18] using top-down lithography and gating. Scalable top-down fabrication readily allows complex geometries and large networks, paving the way toward applications of Majorana devices.

Growth of epitaxial two-dimensional (2D) InAs/Al heterostructures [17] has recently yielded devices with highly transparent superconductor/semiconductor interfaces, as demonstrated by near-unity Andreev reflection probability [18, 19]. In this Letter, we use this hybrid material system to fabricate wire-like structures lithographically. In the presence of an in-plane magnetic field, zero energy states robust in field emerge out of coalescing Andreev bound states, indicative of Majorana zero modes.

A schematic of one of the samples is shown in Fig. 1a, with the heterostructure layers in the inset. The InAs/InGaAs quantum well is close to the surface and covered by a thin layer of epitaxial Al. Large mesas are first etched to isolate individual devices (not shown), then the Al top layer is selectively etched into an effective wire of width $W \sim 100$ nm and length $L \sim 1$ μ m (Fig. 1b). One end of the wire is connected to a large Al plane, serving as measurement ground. On the other end,

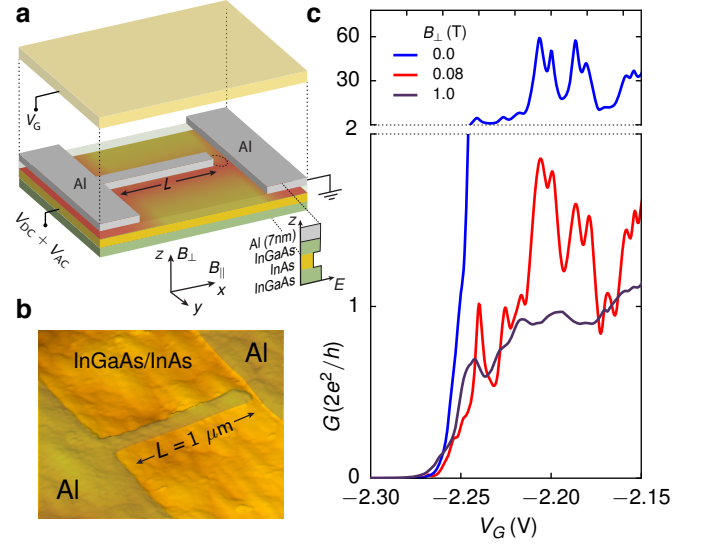


FIG. 1. Device schematic and behavior of the ballistic probe. **a**, Device schematic indicating the aluminum leads (gray), InAs 2DEG (yellow), InGaAs barrier (green) and top gate (orange). The insulating layer between the device structure and the electrostatic gate has been omitted for clarity. The tunneling probe location is indicated by the dashed circle. Inset: band alignment as a function of depth z highlighting the finite confining barrier between the Al and InAs. **b**, False colored atomic force micrograph of a lithographically identical device before ALD and gate deposition. **c**, Conductance as a function of gate voltage for $B = 0$ (blue), $B_{\perp} = 0.08$ T (red) and $B_{\perp} = 1$ T (purple).

a ~ 40 nm gap (indicated by the dashed circle in Fig. 1a) separates the Al wire from the opposing Al plane, acting as voltage source. A global insulating layer and a metallic topgate were then deposited on the entire sample.

Initially, the Al wire is surrounded by conductive 2DEG. Applying a negative potential V_G to the top gate, the wide exposed 2DEG regions adjacent to the Al strip are depleted, leaving a narrow conducting InAs channel strongly coupled to the Al. Due to screening by the surrounding Al, conduction through the constriction persists to more negative gate voltages than the 2DEG planes, resulting in a gate voltage range where wire and Al plane are tunnel coupled. As we will show in the

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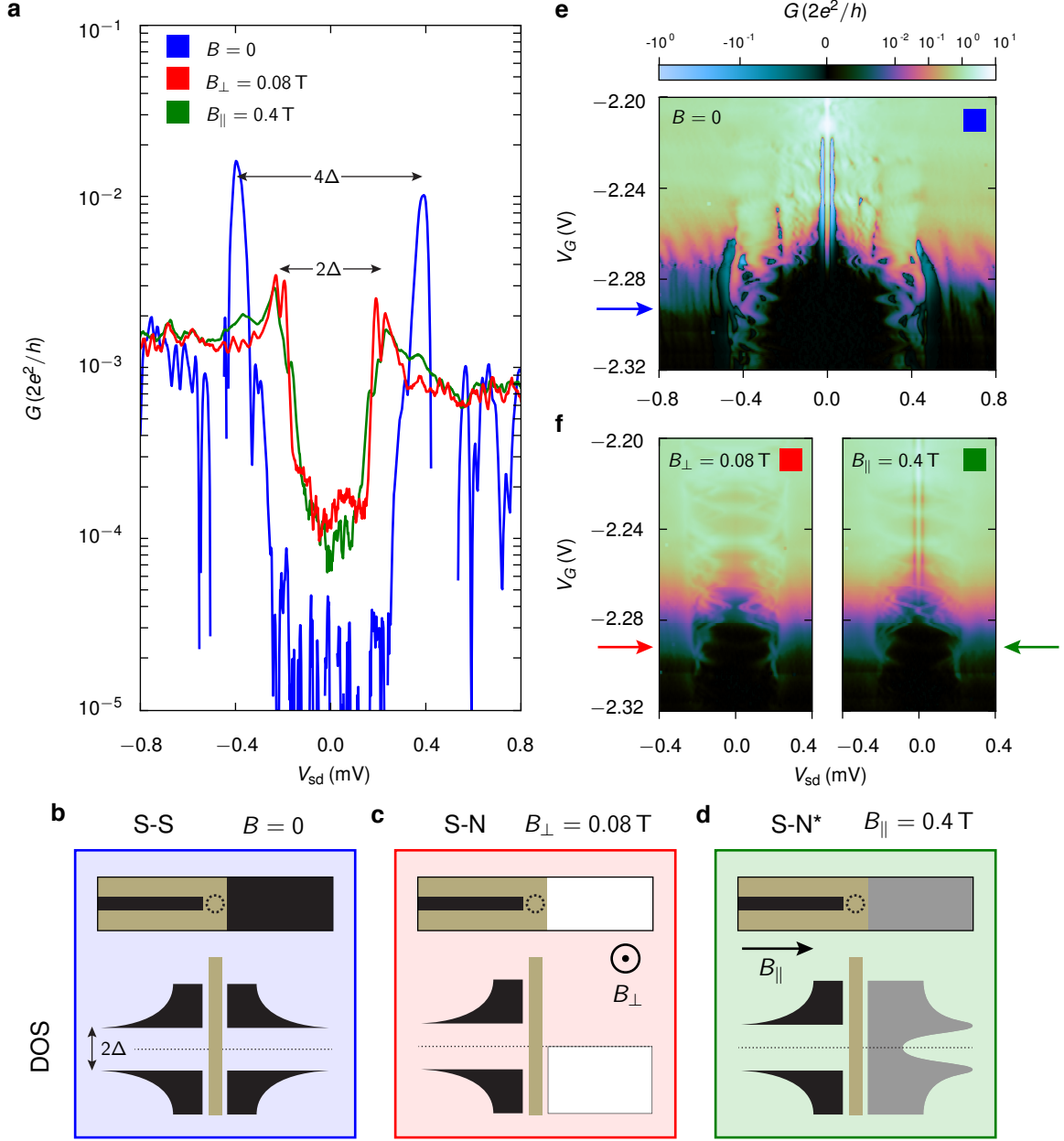


FIG. 2. **Superconducting gap in the tunneling regime and transition to an effective normal probe in a magnetic field.** **a**, Tunneling spectroscopy of the wire for $B = 0$ (blue), $B_{\perp} = 0.08$ T (red) and $B_{\parallel} = 0.4$ T, aligned along the wire (green). **b–d**, Schematic representations of the three regimes of operation shown in **a** with relative DOS in the wire (left) and Al plane (right). Superconducting Al is represented in black, white indicates that the Al has been driven normal and gray that the Al is still superconducting but the induced gap is soft. **e,f**, Tunneling spectroscopy of the superconducting gap for the three field configurations in **a**. The colors from **a** identify each panel, with arrows indicating the gate voltage location of the traces in **a**. A non-linear color-scale is used.

following, the constriction is single mode and ballistic. Furthermore, the asymmetric Al regions allow for a useful (and, to our knowledge, novel) magnetic-field tuning of the device properties. As the Al strip width W is significantly shorter than the superconducting coherence length $\xi_{Al} \sim 1.6 \mu\text{m}$ [20], its critical field is enhanced with respect to the Al plane [21, 22]. It is then possible, by

changing the magnetic field strength and orientation, to tune the wire-plane configuration from superconductor-superconductor (S-S), to superconductor-normal (S-N), to normal-normal (N-N). We give evidence of this tuning both in the open regime (Fig. 1c) and in the tunneling regime (Fig. S1a).

The four-terminal differential conductance of the de-

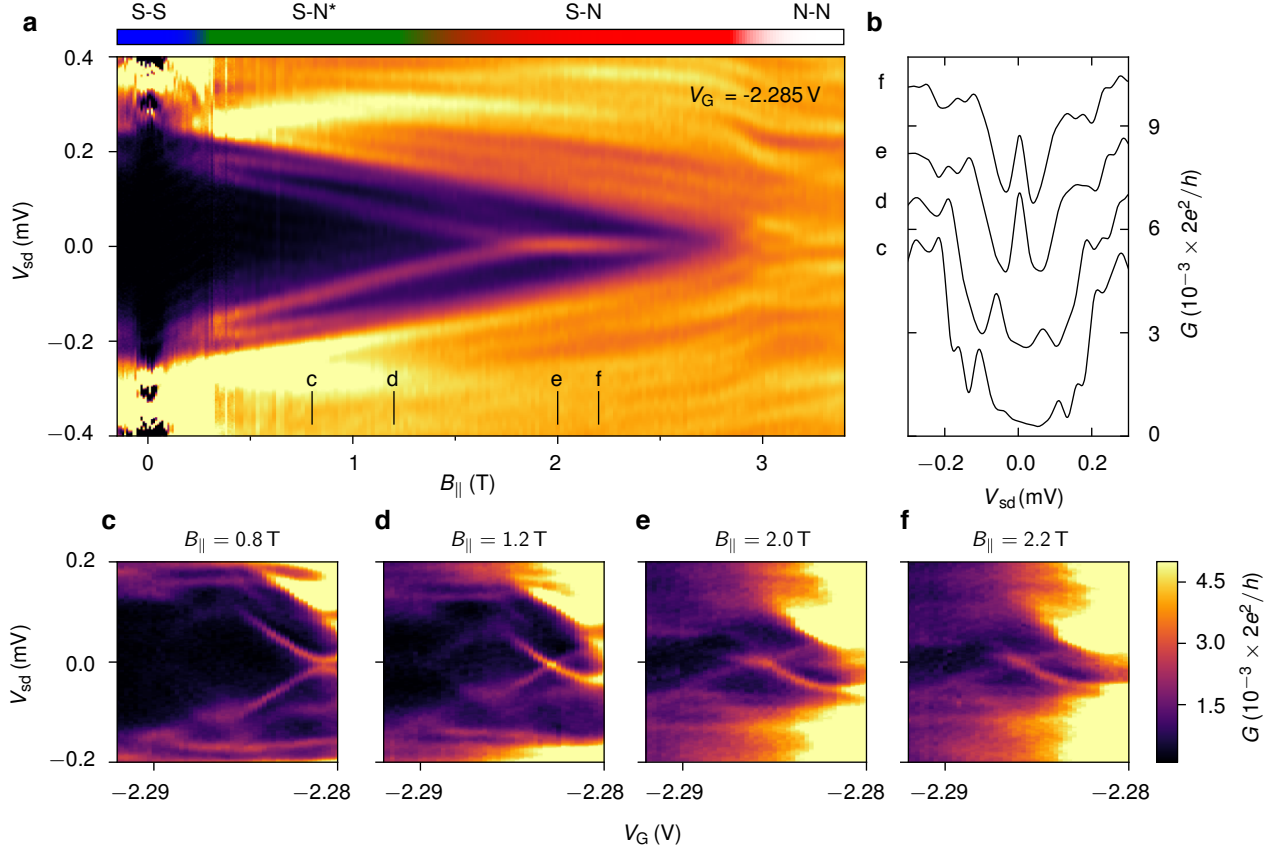


FIG. 3. **Stable zero energy state at large in-plane field.** **a**, Conductance as a function of source-drain bias and parallel magnetic field. The upper colorbar schematically indicates, with reference to Fig. S1, the DOS configuration in the wire and under the 2D plane. The colorscale used is shared with **c–f**. **b**, Line cuts taken at the points indicated in **a**. Curves are successively offset by $2.5 \times 10^{-3} 2e^2/h$. **c–f**, Stability scans as a function of bias and gate voltage at the field positions indicated in **a**.

vice as a function of gate voltage is shown in Fig. 1c. We are interested in the regime close to pinch-off, where the narrow junction is well defined. Applying an out of plane field $B_{\perp} = 1$ T, superconductivity in the whole system is suppressed, resulting in the N-N configuration. Similarly to a conventional quantum point contact, the conductance shows a plateau of $2e^2/h$, demonstrating the junction is single mode and ballistic. In the same gate voltage range, the zero field data (S-S configuration, blue line) shows a conductance increase up to $120 e^2/h$, reminiscent of a supercurrent. Finally, setting B_{\perp} to 0.08 T, the Al plane is driven normal ($B_{\perp,c} \sim 0.06$ T) while the wire persists in the superconducting regime, resulting in the S-N configuration (red curve). In the S-N configuration the conductance plateau approaches $4e^2/h$ as expected in a single-mode S-N junction with high probability of Andreev reflection [23], and recently reported in a similar system [18].

The magnetic tuning of the junction is also evident in the tunneling spectroscopy data shown in Fig. S1a. In the S-S geometry (blue line), the zero field conductance shows a 4Δ gap, owing to convolution of two BCS-like

densities of states with $\Delta = 180 \mu\text{eV}$, as schematically shown in Fig. S1b [24]. In the S-N configuration (red line) the constant density of states in the plane, as shown in Fig. S1c, results in a direct measurement of the superconducting gap of the wire. The full gate voltage evolution in the S-S and S-N scenarios is presented in Fig. S1e and f (left panel), identified by the colored boxes. In both cases, a sharp transition from $G \sim 2e^2/h$ to $G \sim 0$ is observed at large bias, indicative of a clean junction. The S-S configuration also shows, for $V_{sd} = 0$ and $V_g > -2.28$ V, a large conductance peak surrounded by regions of negative differential conductance, which is identified as a supercurrent precursor [25]. Similarly, regular sub-gap features in the open S-S regime are assigned to multiple Andreev reflections. Supercurrent and multiple Andreev reflections disappear in the S-N configuration (Fig. S1f, left panel).

A particularly interesting situation is obtained for an in plane field $B_{\parallel} = 0.4$ T aligned along the wire, well below the critical field of the large Al plane ($B_{\parallel,c} \sim 1.3$ T). Tunneling spectroscopy in this regime reveals a 2Δ gap (green line in Fig. S1a) very similar to the S-N config-

uration discussed previously. On the other hand, conductance in the open regime shows a supercurrent peak (Fig. S1f, right panel), a hallmark of the S-S configuration. This seemingly contradictory scenario is readily explained with a superconducting density of states in the large Al regions developing a soft gap in an in-plane field, as shown in Fig. S1d. In this configuration, referred to as S-N*, the 2D plane stays superconducting, but in the tunneling regime acts as a quasi-constant DOS probing the wire. Independent measurements of the field induced gap softening in a variety of samples are presented in the Supplemental material.

We now focus on probing the wire under conditions relevant for topological superconductivity. To enter the topological phase, a magnetic field aligned perpendicular to the spin-orbit direction must be applied. For a Rashba dominated system, as in the present case, the spin-orbit field is oriented in the plane of the 2DEG and perpendicular to current flow. We thus orient B_{\parallel} along the wire direction. The topological transition is expected at a field $B_T^* = 2\sqrt{\Delta^2 + \mu^2}/g\mu_B$ [2], with μ the chemical potential, g the g -factor of the states in the wire, and μ_B the Bohr magneton.

Figure 3a shows the wire tunneling conductance as a function B_{\parallel} for a top gate voltage $V_G = -2.285$ V, setting the constriction in the tunneling regime. The 4Δ gap observed for $B_{\parallel} = 0$ collapses to 2Δ by $B_{\parallel} = 0.3$ T, attributed to the gap softening under the 2D plane (corresponding to the transition from Fig. S1b to d). The 2D plane evolves continuously from a softened gap (S-N*) into the normal state (S-N) by $B_{\parallel} \sim 1.5$ T. For $B_{\parallel} \geq 2.9$ T, superconductivity in the Al wire is quenched, yielding the N-N state.

Starting from $B_{\parallel} = 0.4$ T a pair of states emerge from the gap edge and linearly approach $V_{sd} = 0$ with an effective g -factor $|g^*| = 2\delta V_{sd}/\mu_B \delta B \sim 4$. At $B_{\parallel} = 1.8$ T the two states merge at zero energy and stick there until the overall gap collapses, at $B_{\parallel} = 2.9$ T. Figure 3b shows line cuts from Fig. 3a at the marked positions. The two states are symmetrically positioned around zero bias, as expected by particle-hole symmetry, but have different amplitudes. This is presumably due to finite voltage effects in conjunction with a spatially asymmetric device. Reverting the source and drain contacts results in a bias reversal of the asymmetry. Similarly to previous results in nanowires [11], the g -factor associated to the Majorana precursors is significantly reduced from that of the bulk semiconductor ($g \sim -12$ for InAs). This is presumably due to the hybrid nature of these states, extending in both Al and InAs.

To emphasize the stability of the observed zero bias peak (ZBP), Figs. 3c-f show gate scans at the marked positions in Fig. 3a. At low field ($B_{\parallel} > 0.4$ T) two sub-gap Andreev states are present, which evolve as a function of bias and field. In Fig. 3e, at $B_{\parallel} = 2.0$ T, these states merge at zero bias over a finite gate voltage range, distinct from the simple point-like crossing in Fig. 3d. Further increasing the field (2.2 T in Fig. 3f) has a neg-

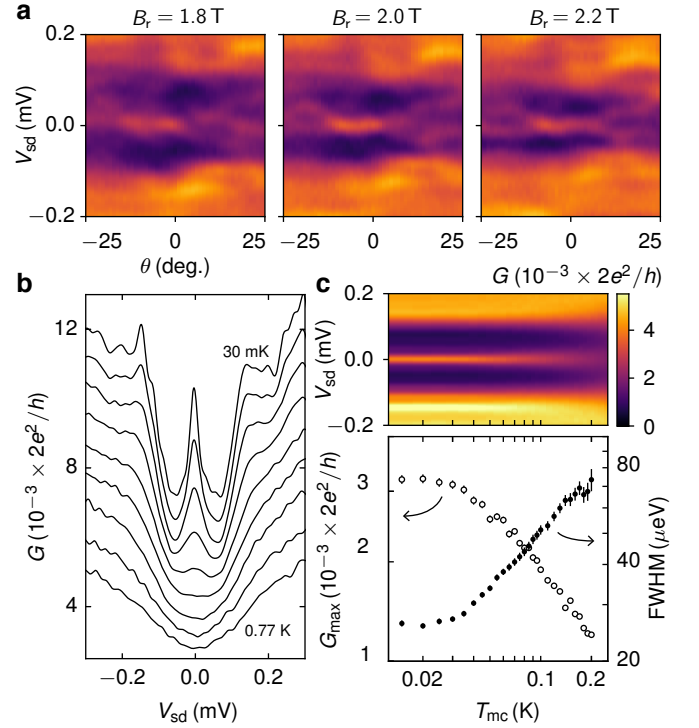


FIG. 4. Stability of the zero bias peak as a function of field angle and temperature. **a**, Conductance as a function of bias and in-plane magnetic field orientation θ for fixed field magnitudes B_r . $\theta = 0$ indicates a field alignment parallel to the wire. **b**, Conductance linecuts as a function of bias for fixed values of the mixing chamber temperature T_{mc} . With decreasing temperature, the ZBP gets sharper and higher. Curves are offset for clarity. **c**, Detailed temperature evolution of the ZBP (upper panel), and extracted ZBP height G_{\max} and full width at half maximum (FWHM) as a function of T_{mc} (lower panel). Note that the vertical axes have logarithmic scales.

ligible effect on the ZBP, with only the bounding gap shrinking slightly.

To further investigate the origin of the ZBP, we vary the magnetic field orientation θ in the 2DEG plane, with $\theta = 0$ being parallel to the wire. As explained above, a Majorana zero mode should only manifest itself for a sufficiently strong field along $\theta = 0$. Figure 4 shows three such rotations for constant magnetic field amplitudes B_r . In all cases, the rotations demonstrate the ZBP stability within a narrow angle range centered at $\theta = 0$, expanding with B_r , consistent with a larger field component perpendicular to \mathbf{B}_{SO} . For larger misalignment angles, the superconducting gap softens and the ZBP splits into two Andreev levels, presumably due to the failure of the topological criterion as the component of $|B|$ perpendicular to \mathbf{B}_{SO} decreases.

Similarly to previous observations [4, 11], the height of the ZBP is significantly reduced from the quantized value of $2e^2/h$, predicted in the absence of disorder at zero temperature [26, 27]. Disorder in our samples is presumably

comparable to conventional nanowires, as suggested by the observation of clear conductance plateaus and a hard superconducting gap. Despite this, the limited gate voltage range over which the ZBP appears is indicative of significant subband mixing, presumably addressable with wafer structures of higher quality. Figure 4c (top panel) shows the evolution of the ZBP of Fig. 3a for $B_{\parallel} = 2.0$ T as a function of mixing chamber temperature T_{mc} , with linecuts shown in Fig. 4b. Consistent with previous measurements of Majorana modes [4], the ZBP is fully suppressed by 300 mK, corresponding to an energy scale for the topological gap on the order $\Delta_{\text{T}} \sim 30 \mu\text{eV}$. The superconducting gap persists up to 1 K, with an overall lifting of the gap background due to thermal quasiparticle excitation. Figure 4c (bottom panel) shows the peak height G_{max} and full width at half maximum (FWHM) for $T \leq 200$ mK, where the quasiparticle background conductance is negligible. Decreasing the temperature, the ZBP gets sharper and its height monotonically increases, with a saturation reached below $T \approx 50$ mK, presumably due to the failure of cooling the electrons further. In this intermediate regime, the peak conductance is proportional to $T^{-\alpha}$, with $\alpha = 0.4 \pm 0.02$ while the peak full width at half maximum (FWHM) scales approximately as G_{max}^{-1} . These observations suggest the ZBP height and width are temperature limited in the present experimental configuration, with the coupling to the leads playing a negligible role.

In conclusion, we have investigated transport signatures of Majorana zero modes in devices defined by top-down lithographic patterning of hybrid InAs-Al two-dimensional heterostructures. Measurements show many features observed in previous studies, including a non-universal zero-bias conductance peak, which appears when an external magnetic field is applied along the wire axis. The scalable fabrication developed here opens the door to complex device geometries and extended networks of Majorana devices.

METHODS

Wafer stack The wafer structure used for this work was grown by molecular beam epitaxy and consists (from top to bottom) of 10 nm Al, 10 nm $\text{In}_{0.81}\text{Ga}_{0.19}\text{As}$, 7 nm InAs (quantum well), 4 nm $\text{In}_{0.81}\text{Ga}_{0.19}\text{As}$, and an InAlAs buffer on an InP substrate [17–19]. The electron mobility, measured in a gated Hall bar geometry with the Al removed, peaked at $20,000 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$ for an electron density of $9.5 \times 10^{11} \text{ cm}^{-2}$. We stress that the

top Al layer is grown directly in the growth chamber, without breaking vacuum.

Sample preparation Utilizing conventional electron beam lithography techniques, mesas were patterned and etched using a typical III-V wet etchant ($220:55:3:3 \text{ H}_2\text{O} : \text{C}_6\text{H}_8\text{O}_7 : \text{H}_3\text{PO}_4 : \text{H}_2\text{O}_2$). Subsequently an etch mask was defined and Al was etched using a selective Al etchant (Transene-D) at 50°C . The devices were then covered with a 40 nm layer of Al_2O_3 grown at 90°C using atomic layer deposition. Finally Ti/Au (5/200 nm) gates were defined and deposited using electron beam evaporation. Four lithographically similar devices were used for this study, of which two showed stable ZBPs in an in-plane field, reproducibly over two cooldowns. Data on the additional devices are presented in the Supplementary Material.

Electrical measurements Measurements were performed using standard DC and low-frequency ($f < 100$ Hz) lock-in techniques in a dilution refrigerator with a base temperature ~ 30 mK. An AC source drain bias of $5 \mu\text{V}$, superimposed on a DC voltage V_{SD} , was applied across the sample while the AC current I_{SD} flowing in the sample and the AC four terminal voltage $V_{4\text{T}}$ were recorded. Conductance measurements shown throughout refer to the quantity $G = \partial I_{\text{SD}} / \partial V_{4\text{T}}$. The magnetic field was controlled using a three axis vector magnet providing a magnetic field up to 6 T along the wire direction and 1 T in the plane perpendicular to the wire. Therefore, field rotations as those shown in Fig. 4a could only be performed in a limited angle range centered around $\theta = 0$.

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AUTHOR CONTRIBUTIONS

F.N. and C.M.M. conceived the experiment. J.S. and C.J.P. grew the wafer. H.J.S., M.K. fabricated and measured the devices with input from A.R.H., C.M.M. and F.N. H.J.S. analyzed the data and wrote the manuscript with input from all the authors.

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Supplementary Material: Scalable Majorana Devices

SINGLE CHANNEL JUNCTION

As shown in Fig. 1c of the main text, the geometry of our sample allows for the formation of a single mode ballistic junction. In case of a junction connecting two normal metals, it is well known that the conductance G_N is proportional to the junction transmission T . This is not the case for a junction connecting a normal metal to a superconductor. In this scenario, the conductance G_S is linked to the normal state conductance G_N by [23]:

$$G_S = 2G_0 \frac{(G_N)^2}{(2G_0 - G_N)^2} \quad (\text{S1})$$

where $G_0 = 2e^2/h$. In our experiments we associate G_S with the zero bias conductance ($G^{V_{SD}=0}$) and G_N with the conductance measured at source drain biases larger than the superconducting gap ($G^{V_{SD}>\Delta}$). Figure S1 shows a parametric plot of $G^{V_{SD}>\Delta}$ versus $G^{V_{SD}=0}$ for various magnetic field configurations studied in the main text, together with the expectation of Eq. S1 (solid black line).

In the S-S configuration (blue dots), $G^{V_{SD}=0}$ largely increases for high transmission due to the presence of a supercurrent (not shown in Fig. S1). On the other hand, for low transmission, the conductance in the S-S configuration is suppressed below the S-N expectation owing to the gapped densities of states on either side of the junction. The regimes attributed in the main text to S-N and S-N* behavior, $B_{\perp} = 0.08$ T (red dots) and $B_{\parallel} = 0.4$ T (red pluses) respectively, are both in good agreement with the theoretical expectation for a single mode S-N junction over two orders of magnitude. For larger in-plane fields (green dots for $B_{\parallel} = 1.0$ T and black pluses for $B_{\parallel} = 1.8$ T), relevant for accessing the topological regime, the superconducting gap softens and the in-gap conductance behaves similarly to the S-N case. This allows us to perform direct tunneling spectroscopy and observe Majorana modes at $V_{SD} = 0$. The softening of the gap for large in-plane magnetic field is consistent with recent experiments on quasi-ballistic nanowire junctions [8]. As a guide to the eye, we also plot the proportional relation expected for a N-N junction (dashed black).

Similar data for another device D2, showing the zero bias conductance as a function of gate voltage for various perpendicular fields is shown in Fig. S2 (cf. Fig. 1).

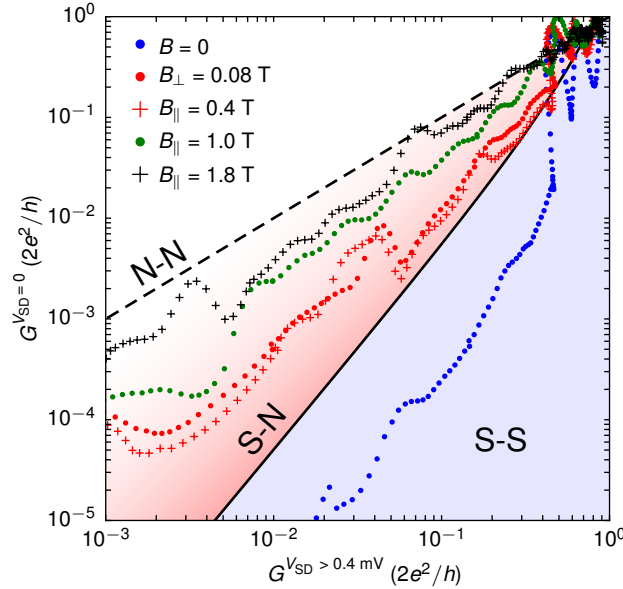


FIG. S1. Zero bias conductance $G^{V_{SD}=0}$ as a function of normal state conductance $G^{V_{SD}>0.4 \text{ mV}}$ in various field configurations. The shaded blue region denotes the expectation for a superconductor-superconductor (S-S) junction. The solid black line is the expectation for a single mode superconductor-normal (S-N) junction [23]. The dashed black line is $G^{V_{SD}=0} = G^{V_{SD}>0.4 \text{ mV}}$ as expected for a normal-normal junction (N-N).

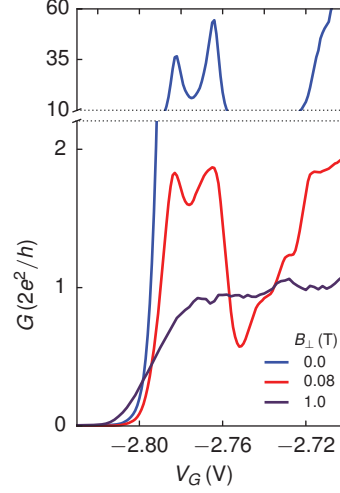


FIG. S2. Conductance as a function of gate voltage measured on device D2 for $B = 0$ (blue), $B_{\perp} = 0.08$ T (red) and $B_{\perp} = 1$ T (purple).

SUPERCONDUCTING TRANSITIONS

To further elucidate the mechanisms behind the magnetic field tuning of our devices, in Fig. S3 we compare spectroscopic data (Figs. S3a-h) in two gate voltage regimes as a function of out-of-plane and in-plane magnetic field (left and right hand side of Fig. S3, respectively). Furthermore, we plot in Figs. S3i,j the resistance of the large Al leads as a function of magnetic field, separately measured in a four terminal configuration. Figures S3a,b show spectroscopic data of the wire for very low coupling ($G^{V_{SD} > 0.4 \text{ mV}} \ll 2e^2/h$), with line cuts at constant V_{SD} shown in Fig. S3c,d. In this case, the gate voltage is more negative than in Fig. 3a of the main text, and no subgap states appear. Figures S3e,f and the line cuts of Figs. S3g,h show results obtained for a more positive gate voltage, setting $G^{V_{SD} > 0.4 \text{ mV}} \approx 2e^2/h$ and allowing the flow of a supercurrent (visible here as a conductance enhancement up to an order of magnitude over the normal state for $V_{SD} = 0$). For perpendicular magnetic fields, the Al planes turn normal at $B_{\perp} = 0.05$ T. This is clearly associated to the 4Δ to 2Δ transition in the tunneling regime as well as the suppression of the conductance enhancement in the open regime. The gap closing and relative rise in the $V_{SD} = 0$ conductance for $B_{\perp} = 0.45$ T marks the collapse of the superconductivity in the Al wire. For an in-plane magnetic field, the 4Δ to 2Δ transition and the suppression of the supercurrent are markedly different, with only the latter coinciding with the critical field of the Al planes ($B_{\parallel} = 1.3$ T). As discussed further with reference of Fig. S4, $B_{\parallel} = 0.3$ T marks instead the typical field scale necessary to lift the hard gap in the superconducting density of states below the large Al planes. Above $B_{\parallel} = 0.3$ T, the wire is effectively probed by a constant density of states.

S-QPC-N AND S-QPC-S

To directly probe the magnetic field evolution of the superconducting density of states below a large Al plane, we perform tunneling measurements from a normal contact (Fig. S4a, S-N configuration) and between two symmetric Al planes (Fig. S4e, S-S configuration). In both cases the tunneling probe is given by two evaporated Ti/Au gates defining a quantum point contact in the InAs 2DEG, similarly to Ref. 18. Tunneling spectroscopy as a function of an in-plane magnetic field aligned along or perpendicular to the current direction (B_{\parallel} and B_t respectively), are shown in Fig. S4b,c,f,g. As expected, the zero field conductance shows a 2Δ gap in the S-N configuration and a 4Δ in the S-S configuration. Further inspection reveals the in-gap conductance suppression for the S-S configuration is much stronger than in the S-N case, as discussed with reference to Fig. S1. In both configurations, an in-plane field above 200 mT lifts the in-gap conductance. In the S-N configuration it is evident the inducing subgap conductance does not influence the gap size, which is largely unaffected for $B < 400$ mT. In the S-S configuration, however, the convolution of the two DOS yields four peaks in conductance at $\pm 2\Delta$ and $\pm \Delta$. As the field is increased further towards $B_{\parallel} = 0.4$ T the $\pm \Delta$ edges are independent of field. In conclusion, both devices demonstrate that for magnetic fields of the order of 400 mT, the superconducting gap measured in a 2D geometry stays roughly constant, however with a significant increase in the subgap conductance.

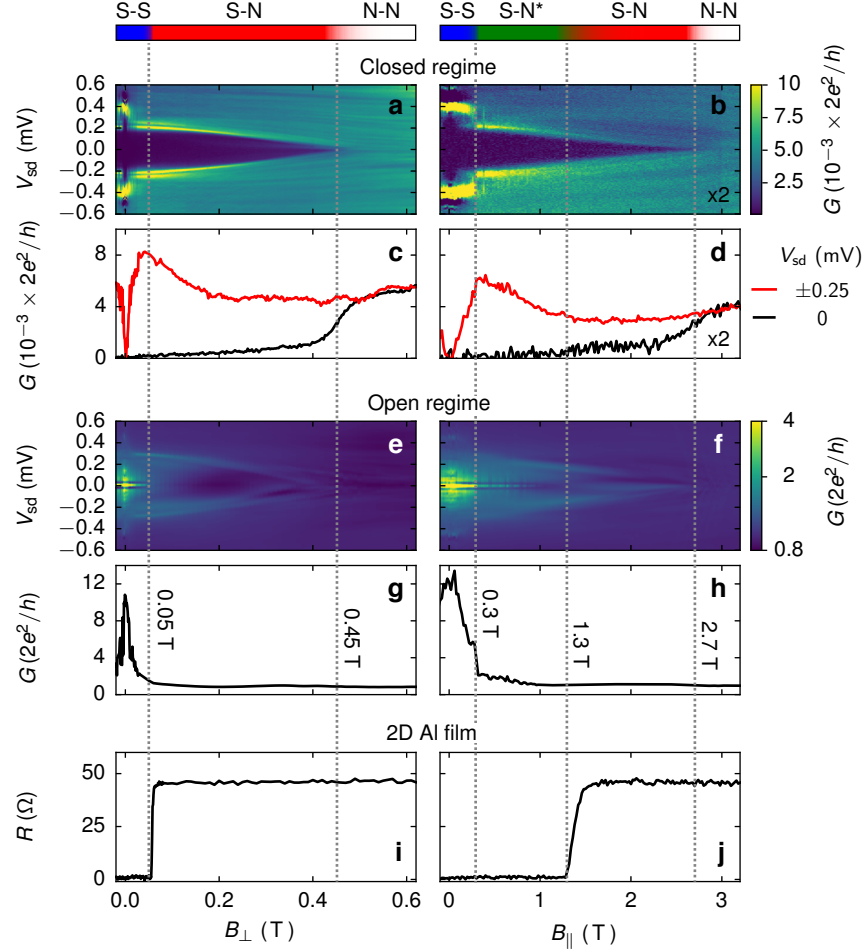


FIG. S3. Conductance as a function of bias and perpendicular (a) and parallel (b) magnetic fields in the tunneling regime. Line cuts are shown in c and d, at both $V_{sd} = 0$ (black line) and $V_{sd} = \pm 0.25$ mV (red). Note that in b and d the conductance has been scaled up by a factor of two to allow for plotting on the same colorscale. Similarly in e–h the dependence of the conductance on magnetic field is shown in the open regime. The resistance of the Al film is shown in i and j for B_{\perp} and B_{\parallel} respectively.

ZBPS IN OTHER DEVICES

Four devices were used for this study, named D1, D2, D3 and D4. Device D1, which showed the highest gate stability, is presented throughout the main text with data shown from cooldown 1. Measurements of D2 showed similar properties to the device presented in the main text, in two cooldowns. Devices D3 and D4 were more disordered and no stable ZBP could be identified. In Fig. S5 we present conductance measurements on three devices (D1, D2, and D3) as a function of V_{SD} and B_{\parallel} . Devices D1 and D2 demonstrate the presence of stable zero energy states in two cooldowns. Device D3 indicates the presence of a superconducting gap masked by disorder, and no ZBP can be identified, similarly to D4 (not shown).

ZBP GATE STABILITY

Fig. S6 shows the gate and bias dependence of the ZBP discussed in the main text at fine gate voltage intervals, indicating its stability over a 3 mV range in gate voltage. Detailed gate dependence of the device behavior at a range of magnetic fields is presented in Fig. S7.

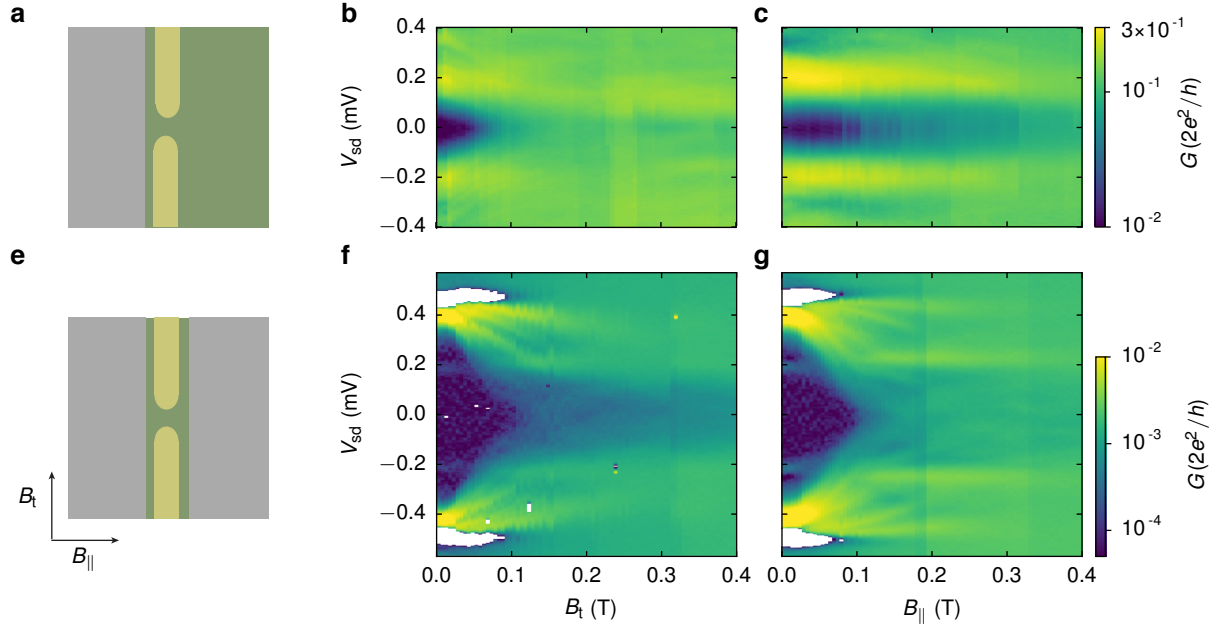


FIG. S4. **a** Schematic of a S-QPC-N geometry with the corresponding field dependence of the measured superconducting gap shown in **b** and **c** for magnetic fields applied along B_t and $B_{||}$ respectively. Both fields are in the plane of the 2DEG as shown in **e**. **e–g** similarly for a S-QPC-S geometry.

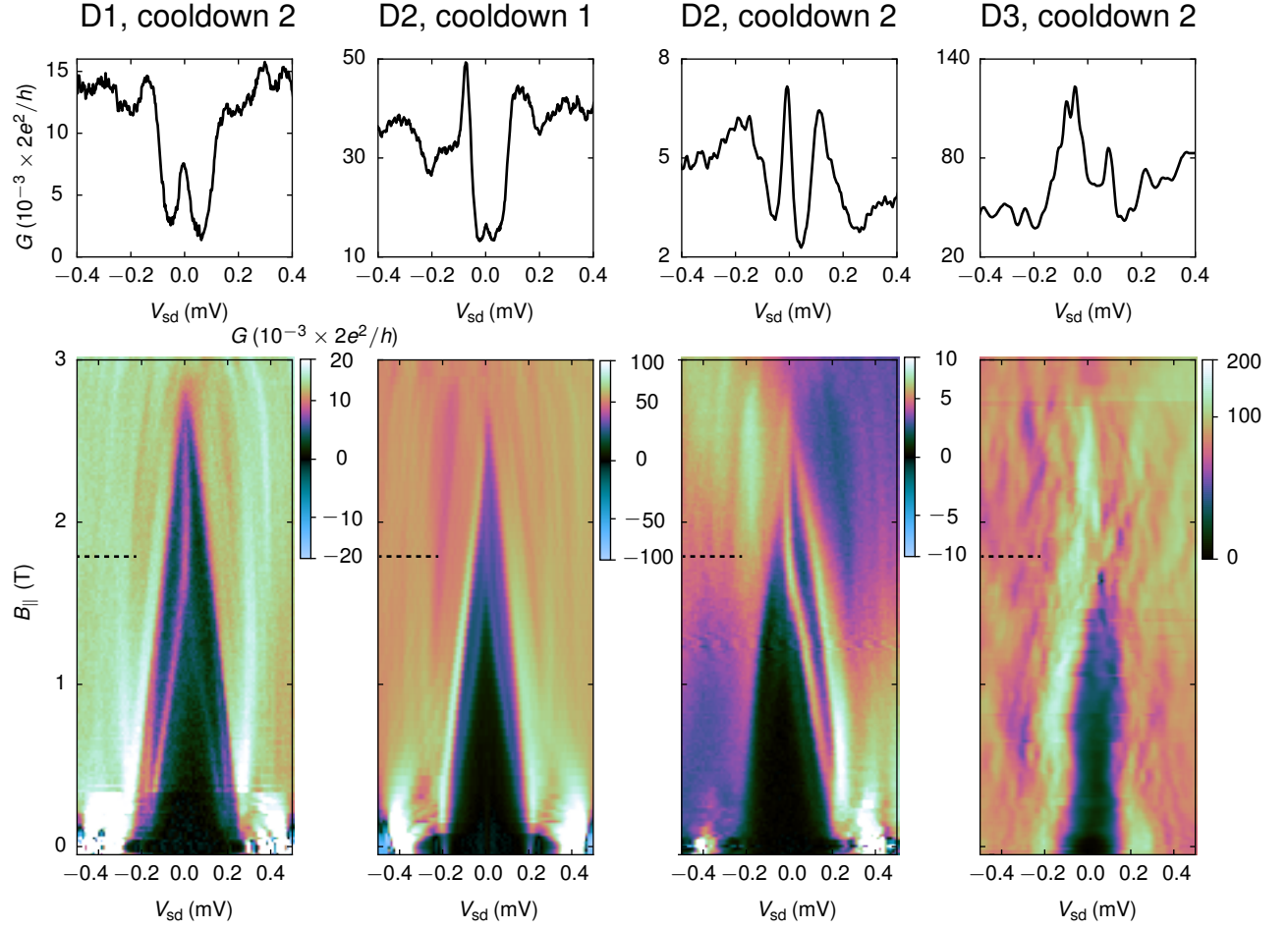


FIG. S5. In three separate devices, characteristic conductance line cuts as a function of bias are shown in the top row taken at $B_{\parallel} = 1.8$ T. The bottom row presents the full conductance maps as a function of magnetic field and bias. The dashed lines indicate $B_{\parallel} = 1.8$ T, the location of the linecuts in the top row. In devices D1 and D2 a ZBP is present, whilst in D3 it is absent presumably due to disorder.

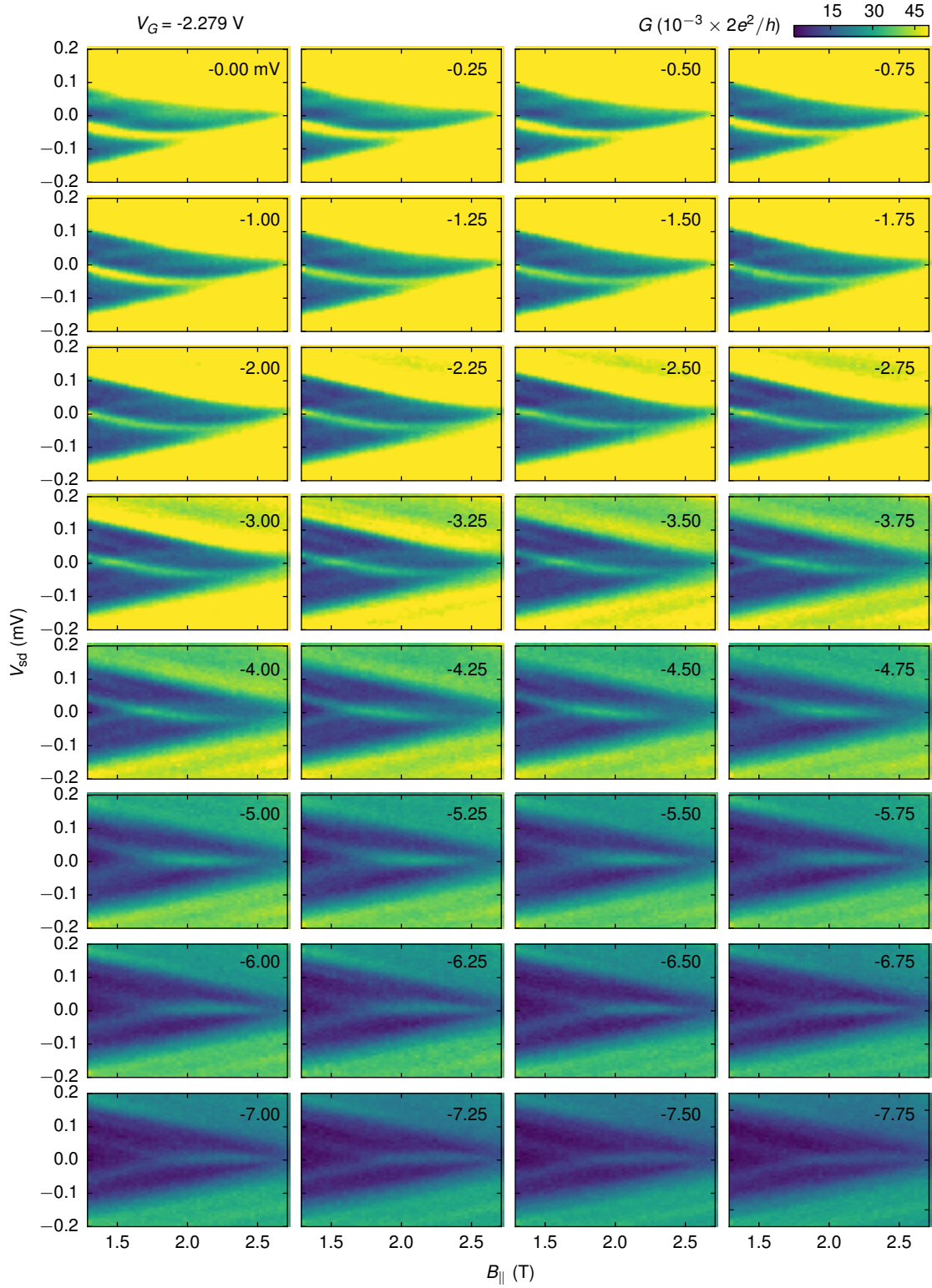


FIG. S6. Snapshots of the bias and magnetic field dependence for a range of gate voltages from $V_G = -2.279$ V to -2.28675 V. The numbers in the upper corner of each panel indicate the gate voltage offset in mV from the starting point.

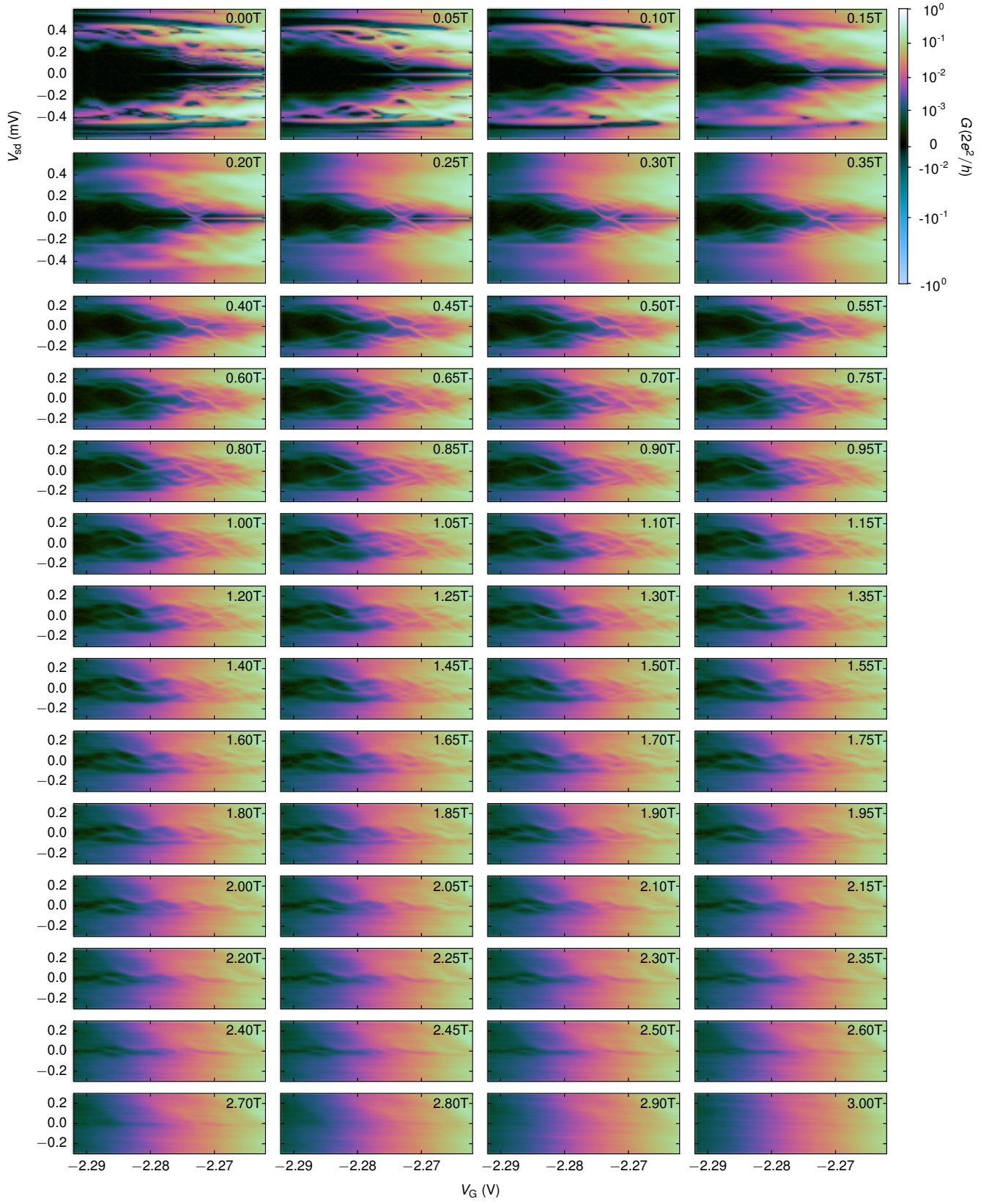


FIG. S7. Snapshots of the bias and gate dependence for a range of magnetic fields indicated in the upper corner of each panel. A nonlinear colorscale is used.